

THREE-DIMENSIONAL STRUCTURE AND EVOLUTION OF THE MIXED LAYER IN THE ARABIAN SEA

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LONG-TERM GOALS

The long-term goal of this effort is to understand better how the upper ocean responds to realistic, spatially complex wind stress patterns. Specifically, upper ocean effects related to both mid-ocean and coastal upwelling are of interest.

SCIENTIFIC OBJECTIVES

The main scientific objective is to understand the physical processes that control the structure and evolution of the mixed layer in the Arabian Sea. Of particular interest are the effects of these variations and processes upon the bio-optical properties of the mixed layer and upper ocean. One of the main hypotheses of the Arabian Sea project is that the large scale structure of the atmospheric fields associated with the Findlater jet determines the mixed layer structure and that the variations across the northern Arabian Sea are due to the cyclonic or anticyclonic nature of the wind field on the two flanks of the jet. We are interested the observed upper ocean structure in various regimes, including both monsoon periods as well as the near-coastal environment off Oman to observe filament structures and comparing them to those observed during the ONR Coastal Transition Zone study.

APPROACH

Our approach was to carry out upper ocean surveys in the Arabian Sea using SeaSoar, a towed undulating vehicle. The system was configured to measure temperature, pressure, conductivity, fluorescence, light transmission, dissolved oxygen, photosynthetically available radiation (PAR) and acoustic backscatter. The surveys took place during 1994 and 1995 along a repeated pattern involving mapping surveys ("radiators") on either side of the climatological Findlater jet, as well as a detailed survey in the vicinity of the moored array (Weller, Rudnick and Eriksen components). Some repeat sampling took place to investigate shorter-scale time dependence, and a filament radiator pattern was executed during the June 1995 cruise. Spatial resolution of the surveys was about 1-2 km horizontally along a cruise track, and about 25 km in the across-track direction. These data are being analyzed in cooperation with Jones (USC) to investigate how the spatial physical and biological patterns evolve and relate to wind forcing.

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WORK COMPLETED

We carried out four cruises in the Arabian Sea:

December 1994 (northeast monsoon), February 1995 (transitional), June 1995 (southwest monsoon), and September 1995 (transitional). We have thus documented the entire upper ocean seasonal evolution for a one-year period. The data from these cruises have now been completely edited, calibrated and archived. We are now carrying out the analysis and writing phase of the project. One paper has been submitted (The Arabian Sea Underway Group, 1997), and we will submit three lead-author manuscripts to refereed journals by the end of 1998.

RESULTS

A paper describing the general physical and optical setting and scales in the Arabian Sea upper ocean is in advanced stages. In addition, we have shown that a cool filamentary structure observed during the summer (coastal upwelling season) has many properties (latitude-scaled size, transport, and nutrient distributions) in common with features off the West Coast of the US. Away from the filament, during the Southwest Monsoon, lateral advection and vertical mixing often obscure the weaker effects of vertical motion driven by surface Ekman pumping. Preliminary estimates using ECMWF wind fields suggest that these offshore vertical displacements are of the order of 20m over a seasonal cycle. In contrast to initial expectations of alternating upwelling and downwelling offshore of the Findlater jet, wind data indicate downward Ekman pumping throughout the year in the region of our offshore radiator, with enhanced downwelling during the Southwest Monsoon.

IMPACT/IMPLICATIONS

We expect that our results will help to explain the evolution of upper ocean physical and biological patterns in the Arabian Sea. By coordination with modeling and other observational groups, we expect that results from this area will deepen our understanding of upper ocean dynamics in other regions as well.

TRANSITIONS

None

RELATED PROJECTS

This effort is a component funded through the ONR Arabian Sea ARI. As such, we have had close cooperations with the moored array group (Weller, Rudnick and Eriksen), remote sensing personnel (Arnone, Coble, Davis), and with biological investigators (Jones, Wood, Yentsch/Phinney). Further, we have cooperated with the NRL numerical modeling team (Kindle) at sea and during the analysis stage.

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